Forecasting the Volume of Investment in Fixed Capital in the Republic of Uzbekistan Using Trend Models

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Abstract: This study provides a comprehensive analysis of the dynamics of fixed capital investment in the Republic of Uzbekistan and develops medium-term forecasts using advanced trend-based econometric approaches. The research examines long-term structural changes, cyclical fluctuations, and growth trajectories in investment volumes based on official macroeconomic time-series data. To ensure methodological rigor, linear, exponential, and polynomial trend models are constructed and comparatively evaluated in terms of goodness-of-fit, statistical significance, and forecasting accuracy. The modeling process incorporates diagnostic testing, residual analysis, and error measurement indicators to enhance reliability and robustness. The findings reveal stable upward tendencies accompanied by periodic volatility driven by structural reforms and external economic factors. Forecast results indicate sustained growth under baseline assumptions, highlighting the strategic importance of investment expansion for industrial modernization and infrastructure development. The study contributes to empirical literature by providing a data-driven framework for investment forecasting and offers practical implications for evidence-based investment policy design, macroeconomic planning, and long-term sustainable economic development.

1 INTRODUCTION

In the context of ongoing globalization and increasing competition, investments in fixed capital are critical for achieving sustainable economic development. They play a key role in expanding production capacity, developing infrastructure, fostering technological innovation, and generating new employment opportunities. Understanding the dynamics of investment volumes and accurately forecasting their future trends is therefore essential for policymakers, investors, and economic planners to make informed decisions and ensure balanced growth.

In recent years, the Republic of Uzbekistan has undertaken comprehensive reforms aimed at improving the investment climate and attracting both foreign and domestic investments. These reforms have contributed to a steady growth in fixed capital investment, which has, in turn, supported the expansion of industrial and service sectors across the country. The Decree of the President of the Republic of Uzbekistan “On the establishment of the U.S.-Uzbekistan Business and Investment Council” highlights the strategic importance of improving regional investment conditions and enhancing forecasting capabilities. Key objectives of this decree include coordinating the development and approval of strategic business initiatives and large-scale investment and trade projects, monitoring their implementation, establishing a special investment fund to attract additional capital, engaging major international financial institutions such as the EBRD, IFC, and ADB to finance infrastructure projects and mitigate risks, continuing negotiations on mutual tariff reductions, and systematically promoting the products and services of IT Park resident companies [1].

This study focuses on analyzing the trends and forecasting the volume of investments in fixed capital in Uzbekistan using quantitative methods, including trend models and ARIMA-based time-series analysis. By providing empirical insights into investment dynamics, the research contributes to a more effective decision-making framework for economic planning and the formulation of policies that support sustainable development in the country.

Among the methods used for time series forecasting, the ARIMA methodology developed by Box and Jenkins is one of the most widely applied and reliable approaches in econometric research. The main advantage of this model lies in its strong statistical foundation, flexibility, and high accuracy in short- and medium-term forecasting. Numerous international studies have demonstrated the effectiveness of ARIMA and SARIMA models in forecasting investment volumes, GDP, exports, and industrial production.

Studies conducted on the economy of Uzbekistan also recognize investments in fixed capital as a key factor of economic growth. Domestic researchers have analyzed investment processes using statistical and econometric methods and have applied trend and regression models for forecasting purposes. However, in many cases, advanced time series models-particularly the ARIMA approach-have not been sufficiently explored in depth.

Therefore, this study considers a more comprehensive analysis of forecasting investments in fixed capital in the Republic of Uzbekistan using trend models, particularly the ARIMA model, to be both scientifically and practically relevant.

To address the problem of time series forecasting, various econometric methods and models are available, among which the ARIMA model is regarded as one of the most reliable and commonly used approaches. The key advantage of this model is that it is constructed by accounting for the stationarity properties of the time series, thereby ensuring the stability and accuracy of forecast results.

In this study, the ARIMA model is employed to forecast the volume of investments in fixed capital in the Republic of Uzbekistan. Initially, the stationarity of the time series representing investment volumes was examined using the Augmented Dickey-Fuller test. To achieve stationarity, the time series was differenced up to the second order, while third-order differencing was avoided in order to preserve the economic interpretation of the data and prevent excessive model complexity.

The optimal orders of the autoregressive (AR) and moving average (MA) components were determined using the Gretl software package. Based on the analysis of the autocorrelation function (ACF) and partial autocorrelation function (PACF), several ARIMA (p, d, q) model specifications were estimated and evaluated in terms of their statistical significance and forecasting performance.

Model adequacy was assessed using the Mean Absolute Percentage Error (MAPE) as a measure of approximation accuracy. In addition, the statistical significance of regression coefficients was evaluated by comparing their p-values with conventional significance levels of 0.1, 0.05, and 0.01. Based on these criteria, the most optimal and reliable ARIMA model was selected.

As a result, medium-term forecasts of investments in fixed capital in the Republic of Uzbekistan were developed using the selected model. The obtained forecast results have significant practical importance for improving investment policy, economic planning, and ensuring sustainable economic growth.

2 METHODS

In forecasting the volume of investments in fixed capital in the Republic of Uzbekistan, the analytical capabilities of Microsoft Excel were also utilized. The analysis was based on official data obtained from the website of the State Statistics Committee of the Republic of Uzbekistan (www.stat.uz), as presented in Table 1 [2].

Table 1: Volume of investments in fixed capital in the Republic of Uzbekistan (billion uzs).

Years	GFCF	Years	GFCF
2010	16463.7	2018	124231.3
2011	19500.0	2019	195927.3
2012	24455.3	2020	210195.1
2013	30490.1	2021	239552.6
2014	37646.2	2022	266240.0
2015	44810.4	2023	356071.4
2016	51232.0	2024	507490.2
2017	72155.2		

It should be noted that the reported 2024 value (507,490.2 billion soums) represents an approximately 42.5% increase over 2023 (356,071.4 billion soums), markedly larger than the year-on-year growth observed in preceding years of the series. This increase is consistent with the officially reported nominal growth in fixed-capital investment for 2024 published by the State Statistics Committee of the Republic of Uzbekistan [2], and predominantly reflects the combined effect of continued high nominal investment growth in national currency terms and elevated domestic inflation/price-level changes over the period, rather than a change in measurement methodology; the data are presented in nominal (current-price) terms throughout this study, and no deflation to constant prices was applied. Because this study models the reported nominal series directly, this acceleration is retained in the data used for trend and ARIMA modeling in the sections that follow, and its influence on the fitted trend and forecast should be interpreted with this nominal-price caveat in mind.

For the experiment, the data were uploaded into MS Excel. After selecting the data range, the "Insert → Chart → Scatter" diagram was chosen. As a result, the corresponding graphical representation was obtained. In modeling the volume of investments in fixed capital in our Republic, we first examine the stationarity of the time series. For this purpose, the time series plot is visually inspected Figure 1.

Based on the visual analysis of Figure 1, the time series appears to be non-stationary. Therefore, the first-order differences of the series were taken, and their stationarity was examined. One of the most widely used methods for testing stationarity is the Augmented Dickey-Fuller (ADF) test (Table 2). This test is designed to detect the presence of a unit root in a time series, allowing us to determine whether the series is stationary or non-stationary. The ADF test is commonly applied in applied statistics and econometrics and belongs to the class of unit root tests. This method was proposed in 1979 by David Dickey and Wayne Fuller.

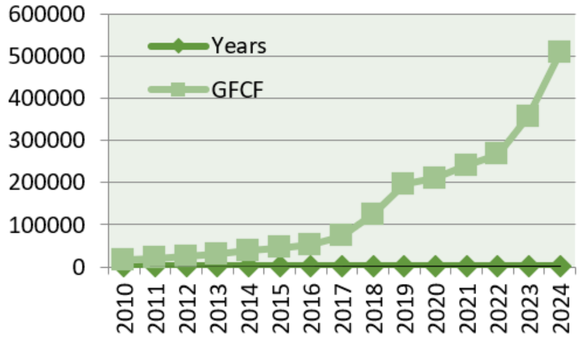

Figure 1: Dynamics of investment in fixed capital in the Republic of Uzbekistan (billion soums).

Table 2 shows that the first-order differences of the series remained non-stationary (ADF test p-value above the 0.05 threshold), whereas the second-order differences (d_d_GFCF) were stationary, with a p-value of 0.008166 for the test with constant, rejecting the unit-root null hypothesis at the 1% significance level. Accordingly, the differencing order d of the ARIMA model is taken as two. At this stage, our model has the following form: *ARIMA (p, 2, q)*.

Table 2: Results of the Augmented Dickey–Fuller (ADF) test for the second-differenced series (d_d_GFCF).

Model specification	Selected lags	Test statistic	p-value	Estimated (a−1)	Stationary
Without constant	4	−0.354	0.5576	−0.842	No
With constant	3	−3.494	0.0082	−5.920	Yes
With constant and trend	4	−3.458	0.0440	−26.495	Yes

Table 3: Results of testing the orders p and q for the ARIMA (p, 2, q) model.

ARIMA (p,2,q)	Test with constant	Grade	Test without constant	Grade
ARIMA (0,2,2)	p-values: 0.0010***; 0.1972; 0.0219** MAPE = 15.999	X	p-values: 0.1055; 0.1733 MAPE = 9.001	X
ARIMA (1,2,0)	p-values: 0.2122; 0.5551 MAPE = 17.76	X	p-value: 0.3668 MAPE = 10.275	X
ARIMA (2,2,0)	p-values: 0.2122; 0.5819; 0.8056 MAPE = 17.72	X	p-values: 0.3690; 0.9844 MAPE = 10.291	X
ARIMA (3,2,0)	p-values: 0.0389*; 0.6707; 0.7014; 0.0711* MAPE = 15.299	X	p-values: 0.3709; 0.9636; 0.2047 MAPE = 9.854	X
ARIMA (2,2,1)	p-values: 8e−021***; 0.0024***; 0.0005***; 0.0585* MAPE = 6.0953	✓	p-values: 0.0657*; 0.0094*** MAPE = 6.5422	✓

In the next step, the orders p and q will be determined. For this purpose, the ACF and PACF correlograms of the level (zero-differenced) series and the second-order differenced time series are examined Figure 2.

According to Figure 2 and Table 3, when determining the ARIMA (p, d, q) parameters based on the ACF and PACF plots, the following observations are made. In the ACF plot, a clear and statistically significant positive spike is observed at lag 1. At subsequent lags, the autocorrelation values gradually decrease and fall within the confidence interval. This indicates that the moving average (MA) component is of low order. Based on these observations, it is reasonable to set q = 1 for the MA component.

In the PACF plot, only the spike at lag 1 is statistically significant, while all subsequent lags are close to zero and lie within the confidence interval. This suggests that the autoregressive (AR) component is limited to first-order.

3 RESEARCH RESULTS

Thus, based on the analysis of the ACF and PACF plots, the most suitable model for the time series is determined as follows:

$$\text{ARIMA } (2, 2, 1).$$

Therefore, we utilize the capabilities of the Gretl software. In Gretl, the “ARIMA lag selection” function is used to experiment with the ARIMA (2, 2, 1) model order Table 3.

According to Table 4, the orders p = 2 and q = 1 are significant based on the Akaike criterion. Therefore, we proceed to experiment with the ARIMA (2, 2, 1) model Table 4. Among the candidate specifications evaluated in Table 4, ARIMA(2,2,1) was selected because it achieved the lowest AIC (368.5852) jointly with statistically significant p and q coefficients; higher-order alternatives such as ARIMA(2,2,2) were also estimated but did not yield a lower AIC and, in several cases, introduced additional coefficients that were not statistically significant, indicating unnecessary model complexity (overfitting risk) without a corresponding improvement in fit. ARIMA(2,2,1) was therefore preferred on standard parsimony grounds (lowest AIC among adequately-fitting, fully significant specifications), consistent with its correspondingly favorable MAPE of 6.0953% reported in Table 3.

According to Table 4, the coefficient φ_1 is statistically significant. Furthermore, as seen in Table 5, all parameters of the model are statistically significant.

The model’s approximation error is MARE = 6.0953%. Additionally, the experiments show that there is no autocorrelation in the residuals. Moreover, the residuals of the model follow a normal distribution Figure 3.

Based on the reliability of this residual distribution, i.e., since it is greater than 0.10, we proceed to consider the forecasting model Figure 4.

The forecast obtained using the model also shows an upward trend in the graph. This reflects that the country’s development is progressing forward [3], [4].

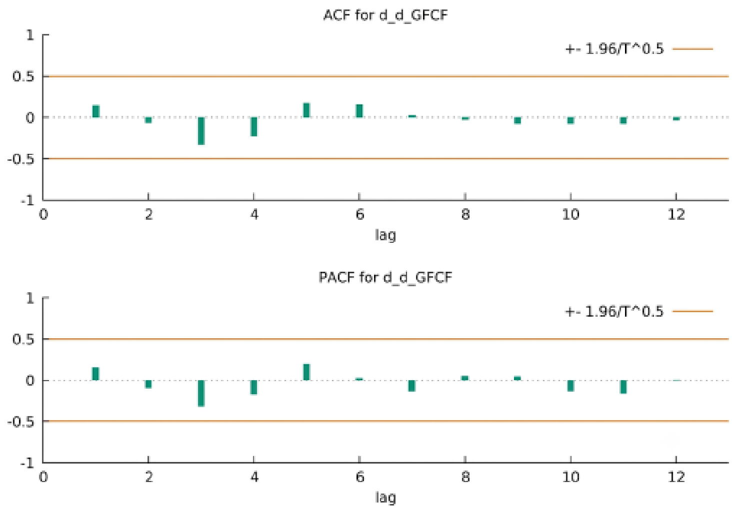

Figure 2: Correlogram of the time series.

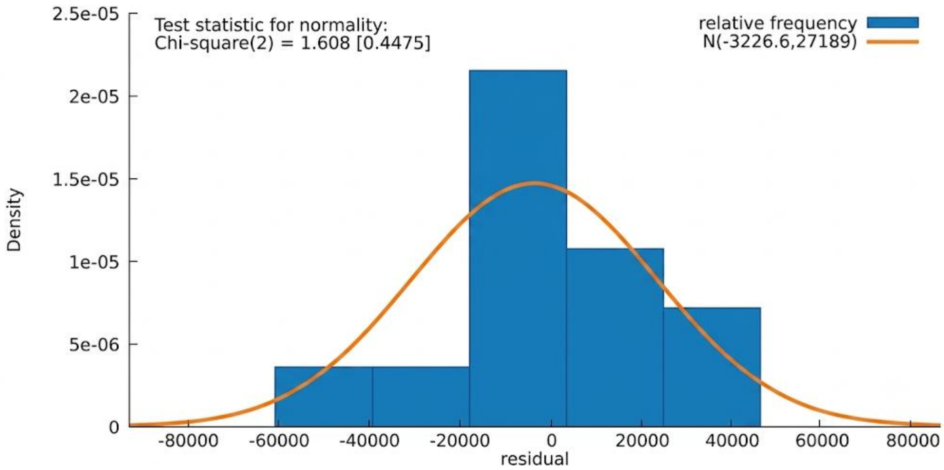

Figure 3: Normality of residuals.

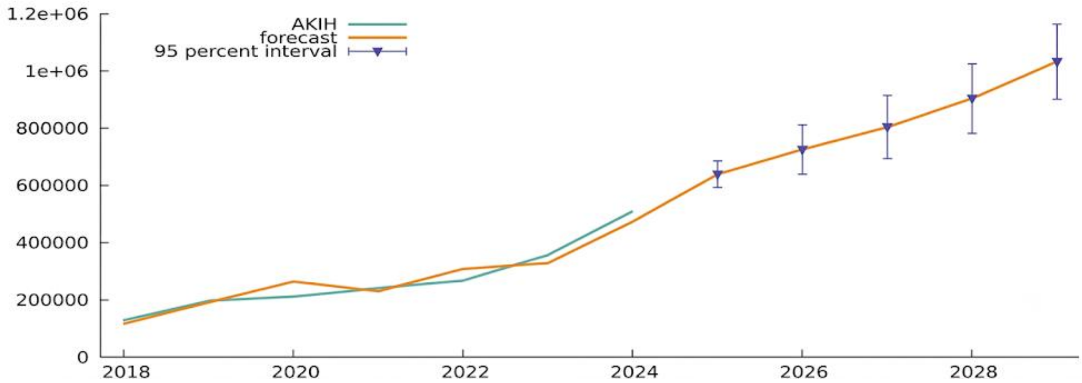

Figure 4: Forecast plot of the model.

Table 4: Comparison of candidate ARMA(p, q) models based on information criteria.

ARMA (p, q)	AIC	BIC	HQC	Log-likelihood
(0,0)	402.473	403.889	402.458	−199.237
(0,1)	391.014	393.138	390.991	−192.507
(0,2)	382.859	385.691	382.829	−187.429
(0,3)	379.306	382.846	379.268	−184.653
(1,0)	378.376	380.500	378.354	−186.188
(1,1)	371.913	374.745	371.882	−181.956
(1,2)	371.765	375.305	371.727	−180.883
(1,3)	368.658	372.907	368.613	−178.329
(2,0)	367.307	370.139	367.277	−179.654
(2,1)	368.585	372.126	368.548	−179.293
(2,2)	369.623	373.871	369.577	−178.811
(2,3)	370.206	375.162	370.153	−178.103
(3,0)	368.549	372.089	368.511	−179.275
(3,1)	370.521	374.770	370.476	−179.261
(3,2)	371.401	376.357	371.348	−178.700
(3,3)	372.089	377.753	372.029	−178.044

Table 5: Results of the regression analysis.

Model 6: ARIMA, using observations 2012-2024 (T = 13)					
Dependent variable: (1-L)^2 GFCF					
Standard errors based on Hessian					
	Coefficient	*Std. Error*	*z*	*p-value*	
const	7715.14	2237.86	3.448	0.0006	***
phi_1	0.677195	0.337355	2.007	0.0447	**
phi_2	−0.543366	0.298757	−1.819	0.0689	*
theta_1	−1.00000	0.266332	−3.755	0.0002	***
Mean dependent var	11414.04		S.D. dependent var	30539.25	
Mean of innovations	−3226.599		S.D. of innovations	22851.49	
R-squared	0.976718		Adjusted R-squared	0.972062	
Log-likelihood	−150.5219		Akaike criterion	311.0439	
Schwarz criterion	313.8686		Hannan-Quinn	310.4633	
	Real	*Imaginary*	*Modulus*	*Frequency*	
AR					
Root 1	0.6231	-1.2050	1.3566	-0.1740	
Root 2	0.6231	1.2050	1.3566	0.1740	
MA					
Root 1	1.0000	0.0000	1.0000	0.0000	

Table 6: Analysis of forecasts and confidence intervals for the volume of investment in fixed capital in the Republic of Uzbekistan (billion soums).

Years	Actual values of the indicator	Theoretical (predicted) values of the indicator	Predicted values of the indicator	Lower bound of the 95% confidence interval	Upper bound of the 95% confidence interval
2010	16463.7				
2011	19500.0				
2012	24455.3				
2013	30490.1				
2014	37646.2				
2015	44810.4				
2016	51232.0				
2017	72155.2				
2018	124231.3	114643.5			
2019	195927.3	187876.4			
2020	210195.1	260121.8			
2021	239552.6	229238.3			
2022	266240.0	305330.1			
2023	356071.4	328119.7			
2024	507490.2	471493.2			
2025		636991.1	22851.49	592203.0	- 681779.2
2026		724867.3	44621.78	637410.3	- 812324.4
2027		803147.7	57578.46	690296.0	- 915999.5
2028		904229.9	63454.76	779860.8	- 1028598.9
2029		1032649.9	66883.16	901561.3	- 1163738.5

Using the ARIMA model in the Gretl software, the volume of investment in fixed capital in the Republic of Uzbekistan (in billion soums) for the period 2010-2024 was forecasted according to the above procedure, and the model took the following form (1):

$$\Delta^2 y_t = 7715.14 + 0.667\Delta^2 y_{t-1} - 0.544\Delta^2 y_{t-2} - \varepsilon_{t-1}, \text{ or, ARIMA } (2, 2, 1).$$

The analysis and forecasting of investments in fixed capital represent one of the key directions in economic studies. Classical and modern economic literature extensively examines the impact of investments on economic growth and the modeling of their dynamics. In particular, the decisive role of investments in macroeconomic development is theoretically substantiated in the Keynesian and Solow growth models [5], [6]. In addition, the relationship between capital accumulation and long-term economic growth is deeply analyzed in endogenous growth theories developed by Romer and Lucas [7], [8]. Empirical approaches to investment behavior and accelerator models are widely discussed in the works of Jorgenson [9], while econometric methods for modeling investment dynamics are comprehensively presented in the studies of Greene [10].

4 CONCLUSIONS

In this study, the dynamics of investment in fixed capital in the Republic of Uzbekistan for the period 2010-2024 were analyzed, and forecasts for 2025-2029 were generated using an econometric ARIMA model (Table 6). The empirical results indicate that the volume of investment in fixed capital has been stable and growing at a rapid pace in recent years. It should be emphasized that these forecasts are conditional on the continuation of historical trend and cyclical patterns captured by the fitted ARIMA model, and are subject to the invertibility caveat noted above regarding the confidence-interval reliability. In practice, the forecasts do not, and structurally cannot, account for external shocks or discontinuities such as global commodity-price or exchange-rate volatility, changes in foreign direct investment inflows, shifts in the domestic investment climate or fiscal/monetary policy, or macroeconomic disruptions of the kind observed historically (e.g., the 2020 pandemic-related downturn reflected in the underlying data); the consistently positive lower confidence bounds through 2029 reflect an extrapolation of past regularities rather than a guarantee against such risks, and the forecasts should accordingly be interpreted as a baseline scenario rather than a risk-adjusted projection.

According to the analysis, there was a significant increase in investment between 2018 and 2024, which can be explained by institutional reforms, improvements in the investment climate, and strengthened government support mechanisms. The theoretical (model-based) values closely match the actual figures, confirming the adequacy of the selected ARIMA model.

The forecast results suggest that the volume of investment in fixed capital is expected to reach 636 991.1 billion soums in 2025, 803 147.7 billion soums in 2027, and 1 032 649.9 billion soums by 2029. The widening of the 95% confidence interval over time indicates increased uncertainty in long-term forecasts. Nevertheless, both the lower and upper bounds of the forecast show that investment activity is expected to continue on a positive trend.

Based on the obtained results, it can be concluded that the volume of investment in fixed capital in Uzbekistan is expected to maintain high growth rates in the coming years. This provides favorable conditions for economic growth, expansion of production capacities, and modernization of infrastructure. From this, the following recommendations are made:

1) Forecast results obtained from the ARIMA model should be used when developing medium- and long-term state programs, particularly for planning the volume of investment in fixed capital.
2) Considering the high uncertainty in long-term forecasts, it is necessary to update and re-evaluate the model annually to improve forecasting accuracy.
3) Alongside nationwide forecasts, regional-level modeling of investment in fixed capital is important for developing regional development strategies.
4) The widening of confidence intervals highlights the presence of external and internal risks in investment processes, emphasizing the need to strengthen legal and institutional measures to stabilize the investment environment.

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